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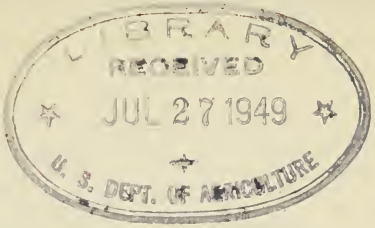

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Hawaii Agricultural Experiment Station

HONOLULU

J. M. WESTGATE, Agronomist in Charge.

PRESS BULLETIN No. 51.

The Spraying of Yellow Pineapple Plants on Manganese Soils with Iron Sulphate Solutions.[1]

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INTRODUCTION.

The yellowing of pineapples on the black manganese soils of the island of Oahu has been a serious problem to the growers for a number of years. The yellowing of the leaves of the pineapple plant, the stunted red or pink fruits,

[1] NOTE:—This press bulletin is a condensation (in popular form) of a forthcoming publication of this station in which the work accomplished is given in much fuller detail, especially as regards its scientific aspects and its relation to other investigations along similar lines. It has been known for a good many years that soils containing excessive quantities of limestone may cause a chlorosis or yellowing of certain plants grown on them. Treatment with iron salts has been used in some cases of such chlorosis of grape vines and fruit trees in France, England, and elsewhere for a number of years. Gile of the Porto Rico Experiment Station [Bul. No. 11 (1911)] found a chlorosis of pineapples on certain Porto Rican soils containing large quantities of calcium carbonate (limestone) derived from coral sand. No manganese has been reported in these Porto Rican soils. Gile found that iron solutions applied to pineapple leaves suffering from this *lime-induced* chlorosis on these limestone soils resulted in the restoration of the green color but he did not consider this method

many of which crack open and decay, and other toxic effects of the manganese soils are familiar to those interested in pineapple culture in the Islands. Previous work by this station has shown that this yellowing is correlated with the presence of abnormally large quantities of manganese in the soil and the characteristic effects of the manganese have been described in previous bulletins of this station.[1]

From a study of the ash analyses of different kinds of plants, it was found that the plants to which the manganese soil appeared toxic, such as pineapple, corn, pigeon pea, etc., have less iron in their ash when grown on manganiferous soils than when grown on normal soils. Ash of such plants as guavas and weeds growing wild on the manganese soils without apparent ill effects showed no decrease in iron, yielding even more iron than when grown on normal soils. The other elements in the ash showed no such significant variation. It thus appeared that the unhealty growth on the manganese soil was due to lack of iron in the plants and that the plants were suffering from iron starvation in spite of the abnormally large quantities of iron present in the manganese soils. A small amount of

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of treatment economically practicable. The name "chlorosis" is a general term for a diseased or unhealthy condition shown by the loss of the green coloring matter. This chlorosis or yellowing may result from a number of causes such as lack of nutriment, poor drainage, bacterial effects, etc. As such a variety of causes may induce a yellowing of the leaves of a plant, and as the manganese soils of the Hawaiian Islands contain no limestone and so small an amount of lime that they are acid to litmus, it had not previously been thought that lack of iron had any connection with the "*manganese yellows*" of the Hawaiian pineapples, especially as the manganese soils are extremely high in iron, containing from 10 to 30% of iron oxide. The presence of such large quantities of iron in the soil seemed to preclude the idea that the plants could be suffering from a lack of iron in their tissues. The line of attack on this problem as outlined in the present bulletin indicated however that the trouble was due in a large part at least to the difficulty of the plant in obtaining sufficient iron in the presence of abnormally large quantities of manganese. It thus apparently remained for this station to work out a practicable method for combating the *manganese-induced* "yellows" or chlorosis of pineapples. J. M. WESTGATE.

[1] Kelley, W. P., Hawaii Sta. Press Bul. 23 (1908); Kelley, W. P., Hawaii Sta. Bul. 26 (1912); Wilcox, E. V. and Kelley, W. P., Hawaii Sta. Bul. 28 (1912).

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iron is necessary for the development of chlorophyl (the green coloring matter of the plant) and the consequent health and vigor of the plant.

Summary of Experiments in Supplying Iron to the Plants.

Experiments in supplying iron salts to the pineapple plants suffering toxic effects on manganese soil have confirmed the conclusions derived from ash analysis, as the

Fig. 1. Front View of Experimental Sprayer.

yellow plants treated became green in a short time and commenced a vigorous growth. The application of solutions of iron salts to the leaves was the only promising treatment. Addition of acids, of solutions of iron salts, and of solid iron salts to the soil appeared of little value. Ferric chlorid (chlorid of iron) gave more rapid results than sulphate of iron (copperas), but because of the much higher price of the former and its tendency to burn the plants, copperas is preferred. Iron sulphate solutions con-

taining a small amount of acid, such as oil of vitriol (Sulphuric acid), acetic acid, or acid waste pineapple juice, were slightly more effective than iron sulphate alone in restoring the normal green color, but more burning to the plants was noticed. The addition of small quantities of nitrate of soda to the solution of iron sulphate applied to the leaves gave slightly more rapid restoration of the green color. Inasmuch as the after-effects of repeated sprayings with mixtures containing nitrate of soda have not as yet

Fig. 2. Rear View of Experimental Sprayer.

been observed it is too early to advise definitely in regard to its use, especially in view of the known injurious effects of sodium nitrate when applied directly to pineapple soils. Sulphate of ammonia similarly added seemed to have no immediate effect, but some benefit may be expected from the part of the spray that reaches the soil.

From a comparison of solutions of various iron salts, of various strengths of solution, of solutions containing acid, of various numbers of applications, and of various methods of application in the treatment of the yellow plants on man-

ganese soil, the most economical and effective treatment appeared to be three or four applications of an approximately 8 per cent solution of iron sulphate (32 pounds of copperas to 50 gallons of water) sprayed from above.

Field Experiments.

The cooperative field experiments in spraying extensive areas of yellow plants on manganese soils with copperas solution have been very successful, the plants becoming green and vigorous. The effect on the stunted red fruit was striking, the normal healthy green color developing and very rapid growth taking place.

The Sprayer Used.

Figures 1 and 2 show the front and rear views of the experimental sprayer used. This sprayer was designed by Mr. Simes T. Hoyt, of the Hawaiian Pineapple Co., and was built at a low cost by the plantation blacksmith. The sprayer is mounted on a single iron wagon wheel so that turning is easy at the end of the rows. A carbonic acid tank in the rear furnishes pressure sufficient for spraying about 80 acres, according to the method used. Recharging the carbonic acid tank costs $4.00. This tank is connected with a 30-gallon tank in front holding the iron sulphate solution. A gauge on the 30-gallon tank shows the pressure, which is kept at about 30 to 40 pounds when spraying. A pipe leads from this tank to the spray nozzles which cover the two rows on either side of the machine. When the sprayer is drawn at a reasonably fast walk, spraying four rows at once and using 13 gallons of solution to an acre, about 20 acres per day are covered.

Spraying Costs.

Since a preliminary newspaper announcement[1] of the benefits to be derived from spraying with solutions of iron

[1] Pacific Commercial Advertiser, Honolulu, T. H., July 21, 1916.

sulphate the plants suffering from "manganese yellows," practically all pineapple plantations on the Islands have experimented with different sprayers using the iron spray. So far success has everywhere been reported. The cost of spraying with all these different sprayers has been considered negligible in comparison with the other expenditures necessary in the raising of pineapples. With the experimental sprayer described above, the cost amounted to approximately 60¢ an acre per spraying. Due to the low cost of spraying, the relative cost of operation of different sprayers need not be compared.

Main Field Experiment.

As the various growers all report success from spraying with iron solution, it is deemed unnecessary to give in this publication all the proofs of the practical value of the treatment. A few details of the main field experiment will be given.

This main experiment was in a large field in Helemanu where the plants were very yellow and were setting the characteristic stunted red fruit. With the exception of the check rows, the part of the field chosen for this experiment was gone over four times with a hand sprinkler containing a solution of 10 pounds of copperas to 50 gallons of water, after which it received three sprayings with the machine described above. Two 330-foot rows were left untreated as checks and two more received only a single spraying. The two rows adjoining the unsprayed rows were held for comparison with them.

The effect of the treatment on the yellow plants was quite striking, both the plants and fruit becoming green, the fruit showing especial stimulation. Figure 3 shows the sprayed and unsprayed rows about a month after the treatment applied in April, 1916. A comparison of the fruit on the unsprayed and sprayed rows indicated the value of the treatment. A short summary of the yields on the sprayed and unsprayed rows is given in the following table:

RESULTS OF SPRAYING PINEAPPLES ON HIGHLY MANGANIFEROUS SOILS WITH IRON SULPHATE SOLUTIONS.

	Unsprayed rows.	Rows receiving single spraying.	Rows receiving full iron spray treatment in April.
Plants from which fruit was harvested	108	151	244
Plants bearing fruit too young to harvest	0	5	9
Plants blossoming	3	1	11
Plants starting to bloom	0	0	36
Plants dead	31	0	0
Plants with fruit cracked open and decayed	101	81	0
Plants very yellow with no evidence of blosson	57	62	0
Total	300	300	300
Total weight of fruit harvested ..... pounds	310¼	431 15/16	774⅜
Average weight of fruits ..... "	2¾	2⅞	3 3/16
Fruits harvested	108	151	244
Fruits classed as "first" or No. 1 [1]	39	75	214
Fruits classed as "second" or No. 2 [1]	69	76	30
Fruits classed as No. 1 ..... per cent.	36.1	49.6	87.7
Weight of No. 1 fruit ..... pounds	128 11/16	250 7/16	700 3/16
Weight of No. 2 fruit ..... "	181 9/16	181½	74 3/16
Total weight of fruit ..... "	310¼	431 15/16	774⅜

[1] Cannery classification by diameter.

Discussion of Table.

An examination of the table shows the practical value of the iron spray treatment. Full details of this experiment will be given in the larger forthcoming publication of this station.

Figure 4 shows the sprayed and unsprayed rows (June

Fig. 3. Main Field Experiment (May 19, 1916). Rows Sprayed in April (on right) vs. Unsprayed Rows (on left).
(Note the diminutive stunted fruits on the left. The photograph fails to show the yellow color of the unsprayed plants.)

30, 1916). This view is taken about half way along the rows looking south. On the unsprayed row can be seen the plants classified in the table as (a) bearing decayed fruit, (b) very yellow with no evidences of blossom, and (c) as plants dead. Nearly all the fruits from the unsprayed rows had to be classed as No. 2, because of their small diameter and undesirable shape. Besides this, the very inferior quality of the manganese fruit is well known. The cylindrical development of the fruit observed in the sprayed rows is much desired by the canneries, as this shape causes least waste in sizing for the cans.

Although the rows receiving a single spraying had only a slight greenish tinge, an increase in yield from the single spraying is to be seen from the table.

Practical Advice as to the Treatment of Manganiferous Soils.

Although the table demonstrates the practical value of iron spray treatment, even when applied, as in this case,

Fig. 4. Main Field Experiment (June 30, 1916). Sprayed Rows (on left (and characteristic effects of manganese soil in unsprayed rows (on right).

to plants suffering during the greater part of their period of growth from lack of sufficient iron, such late sprayings are, however, not advised. The following is a suggested plan of procedure.

Give young planting on manganese soil a single spraying every two to four months, using the color and appearance of the plants as an indication of their need of spraying. Spray the plants when any indications of yellowing or other ill effects appear, the idea being to give the plants sufficient

iron to keep them green and healthy. Give plants that are already yellow three or four sprayings at intervals of a week, and spray as necessary to keep them green and healthy.

For the present the use of iron sulphate only in the spraying solution is recommended. The application of small quantities of a fairly strong solution in the form of a fine mist appears most effective and economical. No injurious burning effects have been observed even on young plants.

For this method of application, dissolve about 32 pounds of copperas crystals in 50 gallons of water and apply at the rate of about 13 gallons per acre. For sprayers which take larger quantities of solution to cover an acre, use less copperas to the 50 gallons of water, the idea being to apply about 10 pounds of copperas per acre per spraying.

In the preparation of the manganese soils, when commercial fertilizers are to be used, soluble phosphates and nitrogen as sulphate of ammonia or in organic forms are recommended. Nitrate of soda should not be used. Where stable manure or other humus-forming materials can be applied at a reasonable cost, their use is advised.

The decreasing yield of pineapples with the continuous cropping of non-manganese soils is well known and it is improbable that the manganese soils will continue to give satisfactory crops indefinitely with the iron spray treatment alone. It is probable that the same practices developed for maintaining good yields on the non-manganese soils will also have to be applied to the manganese fields in addition to the iron spray treatment. The management of pineapple soils to maintain the yields has been discussed by Kelley in Press Bulletin No. 29 of this station. The addition of organic matter to the soil and proper provision for suitable drainage at present seem to offer the most promise for the overcoming of the tendency to reduced yields under continuous cropping.

With no method of preparation of the highly manganiferous soils so far tested does the plant seem to absorb

sufficient iron, and the iron spray treatment should be applied as soon as any signs of yellowing appear.

Thanks are due and are hereby extended to Mr. J. M. Westgate, director of the station, for heartiest support in this investigation, and to Messrs. J. T. Whitmore, Simes T. Hoyt, and H. Bloomfield Brown, of the Hawaiian Pineapple Company, for their thorough cooperation and help.